

GROWTH OF LITERATURE ON AERODYNAMIC RESEARCH: A SCIENTOMETRICS STUDY

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ABSTRACT

The study deals with scientometric study on the Growth of Literature on Aerodynamic Research. The required data was collected from SCOPUS database for the period 2006 - 2015. It can be seen that nearly 41628 bibliographic records of contribution in field of Aerodynamic cover the period of 10 years. The researcher applied the search strings “(KEY (Aerodynamics) AND PUBYEAR > 2005 AND PUBYEAR < 2016)” that has used for the data extraction from the database downloaded the records based on the above strings. A total of 41628 records were downloaded and analyzed by using the Excel software with application as per the objectives of the study. This research study explores the growth rate and relative growth level during the study period. The study aims to analyze the thrust areas of research concentration on Aerodynamic research. It is analytical in nature with the suitable statistical tools applications in strengthening the empirical validity. The study based on Scopus bibliographic database has been used and searched using the word “Aerodynamic” for the period 2006-2016 and extracted 41628 records with full bibliographical details such as Title, Authors, Source, Year, Country, Subject, Language and so on

KEYWORDS: Aerodynamic, SCOPUS Database, Scientometric, Growth, Literature & CAGR

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INTRODUCTION

Scientometrics is used to quantify scientific activities. Generally quantification of scientific activities is measurable by producing statistics on scientific publications indexed in indicator databases such as SCOPUS, Web of Science. Scientometric data can be useful to measure research collaborations among scientific environments and to monitor the evolution of special scientific subject and fields. Also decision and policy –makers are going to be interested in scientometric indicators. The major sub-fields of Aerospace are: Aerospace Engineering, Aerospace Medicine, Computer Simulation, Space flight, Aerospace applications, Mathematical models, Space research, Aircraft, Spacecraft, Optimization, Algorithms, Satellites, Aerospace vehicles, Aviation, Remote sensing, Computer Software, Aerodynamic, Computer Networks and Robotics. Being that "gas dynamics" applies to the study of the motion of all gases, and is not limited to air. Aerodynamics (Wikipedia, 2017)¹ derived from Greek word (air) and (dynamics), the study of the motion of air, particularly it interaction with a solid object, such as an airplane wing. Aerodynamics is a sub-field of fluid dynamics and gas dynamics, and many aspects of aerodynamics theory are common to these fields. The term *aerodynamics* is often used synonymously with gas

dynamics, the difference. In this study the literature published specially in the Aerodynamic fields, and covered in SCOPUS database has been analyzed.

OBJECTIVES

The major objectives are framed with the exclusive notion of the present study as mentioned below:

- To examine the growth of research productivity of Aerodynamic during 2006- 2015
- To identify the Document type of publications
- To find out the Journal distribution of publications in Aerodynamic
- To study the subject-wise breakup of publications
- To identify country-wise distribution of publications and
- To assess the form of communication and language wise research concentration of Aerodynamic.

METHODOLOGY

The research design is analytical that adopt detailed analysis of secondary data using a range of scientometric tools, techniques and formula along with standard statistical techniques. The required data was collected from the SCOPUS database. Scopus is the largest abstract and citation databases of research publication and quality web resources. Scopus provides superior support of any literature research process. The data is updated regularly. The database also helps the research and find innovative tools that give an at – a – glance overview of search results. A total of 41628 records were analyzed by using the Excel software with application as per the objectives of the study.

Compound Annual Growth Rate (CAGR)

According to Choi et al., (2011)², Growth rate is being measured with Compound Growth Rate (CAGR). The mathematical formula of CAGR is as follows

$$CAGR = \frac{\left(\frac{\text{Ending Value}}{\text{Beginning Value}} \right)^{1/n} - 1}{1}$$

REVIEW OF LITERATURE

Scientometrics can be defined as the “quantitative study of science, communication in science, and science policy” (Hess, 1997)³. Scientometrics is the science of measuring and analyzing science. In practice, Scientometrics studies has been done using bibliometric methods (Wikipedia, 2014)⁴. Pritchard (1969)⁵ defined Bibliometrics as “*the application of mathematical and statistical methods to books and other media of communication*”, while Nalimov and Mulchenko (1969)⁶ defined Scientometrics as “*the application of those quantitative methods which are dealing with the analysis of science viewed as an information process*”.

Gupta and Adarsh Bala (2010)⁷ analyzed Indian Science and Technology publications of 1996-2010. This study conducted on the basis of Scopus database and examined several quantitative measures including India’s global publication

share, rank and growth rate, its publication share in various subjects in terms of national and global context. The study found that India contributed 538609 papers in science and technology during 1996 to 2010 with an annual average growth rate of 9.32 per cent. The study found that top 100 most productive Indian organisations contributed 54.92 per cent share (295827 papers). The study shows that among the India's contribution to global research output in broad 20 subjects during 1996-2010, the largest publications share (5.49 per cent) comes from veterinary science.

Van Raan (1997)⁸ argued that the core research activities of scientometrics fall in four interrelated areas: science and technology indicators, information systems on science and technology, the interaction between science and technology, and cognitive as well as socio-organisational structures in science and technology. He emphasizes that an essential condition for the healthy development of the field is a careful balance between application and basic work, in which the applied side is the driving force. In other words: scientometrics is primarily a field of applied science. This means that the interaction with 'users' is at least as important as the interaction with colleague-scientists. He states that this situation is so stimulating, it strengthens methodology and it activates basic work. He considers the idea of Scientometrics lacking theoretical content or being otherwise in a 'crisis-like' situation as groundless. Scientometrics is in a typical developmental stage in which the creativity of its individual researchers and the 'climate' and facilities of their institutional environments determine the progress in the field and, particularly, its relation with other disciplines.

The study carried out by Bagalkoti (2013)⁹ on Scientometric analysis of Indian science publication output as reflected in Scopus Database found that 7,01,900 papers received 36,65,095 citations during the period 1997-2011. India was ranked 10th among the 50 productive countries of the world in Science and Technology. The study shows that global publications share of India during 1997-2011 was 2.73%, which has increased from 1.93 in 1997 to 4.00 in 2011 and India has published 1,59,110 (22.29%) international collaborative papers. As per the study Physical sciences subjects together contributed the highest publications share (57.59%), followed by Life Sciences (26.91%), and Medicine (15.51%). The study found that Indian Institute of Science contributed the highest publications, i.e., 26161 articles with 14.41% to total output and among universities, the largest number of papers 11685 (4.81%) is published by Jadavapur University, followed by Banaras Hindu University 11680 (4.80%).

Biswas, S K. and Akhtaruzzaman, M (2012)¹⁰, have found that, a detail Scientometric analysis of medical research performance of Bangladesh and its comparison with other countries is very important to obtain a clear picture and to take necessary measures to upgrade our research performance. At the same time it is also very important to evaluate the research performance of major medical research institutes of the country and to compare their performance among themselves and similar institutes of other countries.

According to Rasolabadi, M., et al., (2015)¹¹, the aim of this study was to analyze Iran's research performance on diabetes in national and international context. This Scientometric analysis is based on the Iranian publication data in diabetes research retrieved from the Scopus citation database till the end of 2014. The study found that Iran's cumulative publication output in diabetes research consisted of 4425 papers from 1968 to 2014, with an average number of 96.2 papers per year and an annual average growth rate of 25.5 per cent. Iran ranked 25th place with 4425 papers among top 25 countries with a global share of 0.72 per cent. Average of Iran's publication output was 6.19 citations per paper.

DATA ANALYSIS

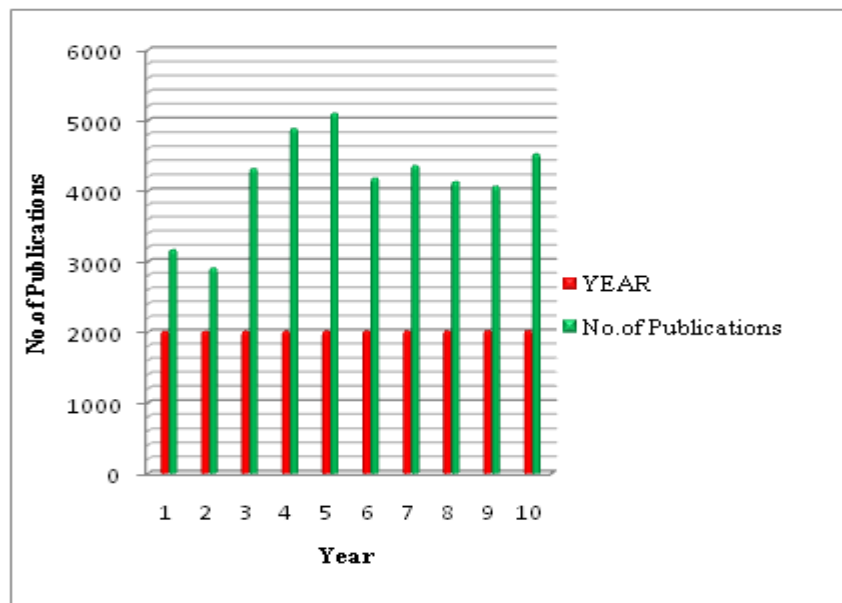
Year Wise Publications

The year wise distribution of aerodynamic research publications is given in Table 1.

Table 1: Year Wise Publications

S. No	Year	No. of Publications	%	CAGR
1	2006	3164	7.6	
2	2007	2908	6.98	-8.09
3	2008	4316	10.37	48.42
4	2009	4883	11.73	13.14
5	2010	5099	12.24	4.42
6	2011	4181	10.04	-18.00
7	2012	4359	10.47	4.26
8	2013	4131	9.93	-5.23
9	2014	4064	9.77	-1.62
10	2015	4523	10.87	11.29
	Total	41628	100	

The Table 1 and Figure 1 shows that a total of 41628 research publications in Aerodynamic during 2006 – 2015 were published with an average 4162 papers per year. The maximum number of publications is in 2010 with 5099 papers. Regarding Compound annual growth rate (CAGR), Maximum CAGR observed in 2008 and negative growth observed in 2007, 2011, 2013 and 2014.

**Figure 1: Year Wise Distribution of Publications**

Prolific Countries

There are 41628 contributions available in SCOPUS database. The country wise production of papers in Aerodynamic is shown in Table 2.

Table 2: Prolific Country with No. of Papers

S.NO.	Country	No. of Publications	% of 41628
1	United States	11551	27.75
2	China	11129	26.73
3	United Kingdom	2683	6.45
4	Germany	2538	6.09

Table 2: Contd.,			
5	Japan	2474	5.94
6	France	1901	4.57
7	Italy	1513	3.63
8	Canada	1373	3.29
9	Russian Federation	1127	2.71
10	South Korea	1090	2.69
11	India	1005	2.41
12	Australia	968	2.33
13	Netherlands	765	1.84
14	Spain	683	1.64
15	Sweden	544	1.31
16	Iran	543	1.3
17	Brazil	463	1.11
18	Taiwan	431	1.04
19	Switzerland	422	0.99
20	Belgium	412	0.98
20	Turkey	287	0.68
21	Israel	285	0.68
22	Denmark	281	0.67
23	Poland	233	0.56
24	Hong Kong	220	0.53
25	Greece	3997	9.6
Total		48918	117.52

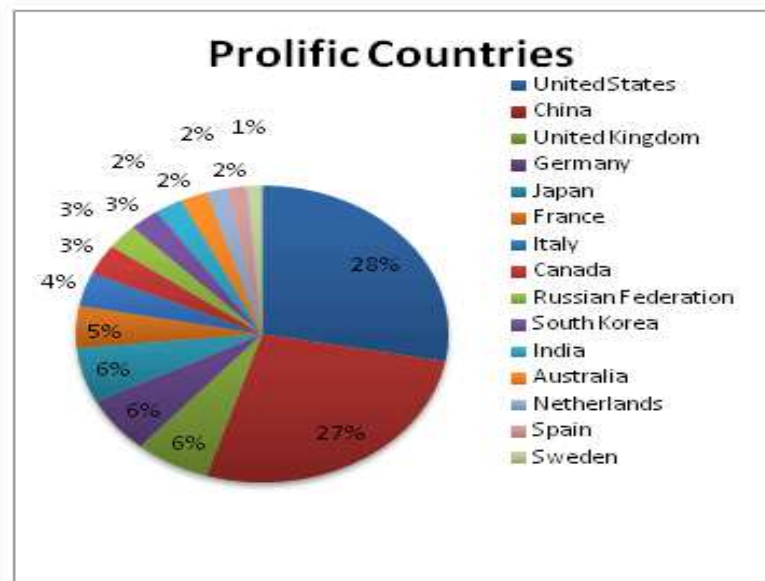


Figure 2: Prolific Country

It is seen from Table 2 (Figure 2) that collaborative research has been carried out in the research area Aerodynamic beyond the territory. Most of the contributions are collaborative research i.e. 7290 contributions seem to be the joint contributions of two or more countries. Developing countries contributing are China (11129), United Kingdom (2683), Germany (2538) and Japan (2474) positioned in top five Prolific Countries in Aerodynamic research. Table 2 also shows that India has Eleventh position in this study.

Document Type

There are different Bibliographic forms such as Conference paper, Article, Review, Article in Press, Conference

Review, Book Chapter, Short Survey, Letter, Note and Editorial forms. The distribution of research production in these forms is Table 3.

Table 3: Document Type

S. No	Document Type	No. of Publications	%
1	Conference paper	20732	49.8
2	Article	20339	48.84
3	Review	313	0.77
4	Article in Press	117	0.28
5	Conference Review	70	0.17
6	Book Chapter	28	0.07
7	Short Survey	23	0.06
8	Letter	3	0.01
9	Note	2	0
10	Editorial	1	0
	Total	41628	100

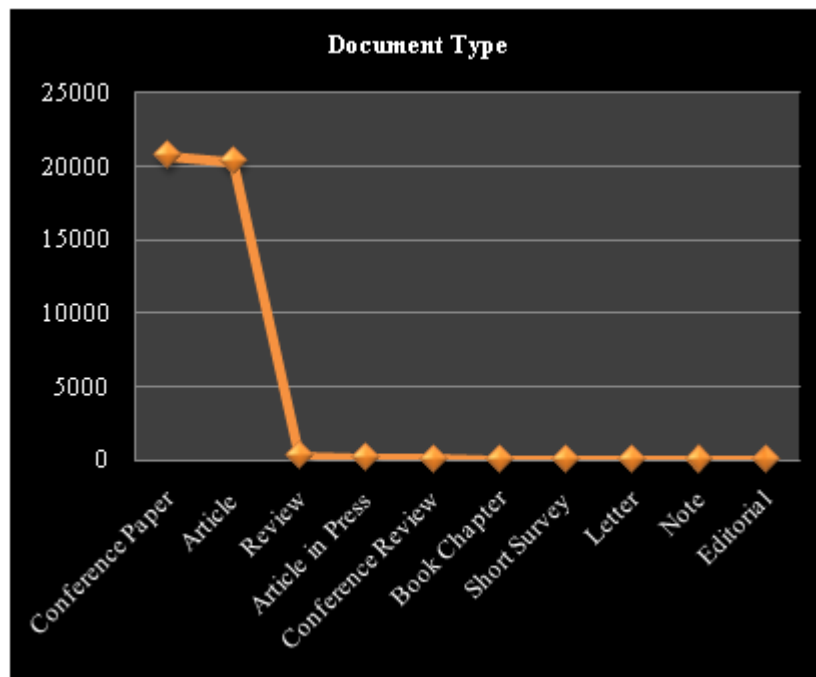


Figure 2: Document Type

The research productions have been contributed in 10 forms of bibliographical formats and Conference paper and Articles occupy most of the publications. They occupy 98.64% (Figure 3) of the worldwide publications.

Language Wise Distributions

Language wise distribution of publications in Aerodynamic is shown in Table 4.

Table 4: Language Wise Distribution

S. No	Language	No. of Publications	%
1	English	36030	86.55
2	Chinese	5161	12.39

Table 4: Contd.,			
3	Japanese	295	0.72
4	Korean	44	0.11
5	German	41	0.09
6	French	25	0.06
7	Others	32	0.08
Total		41628	100

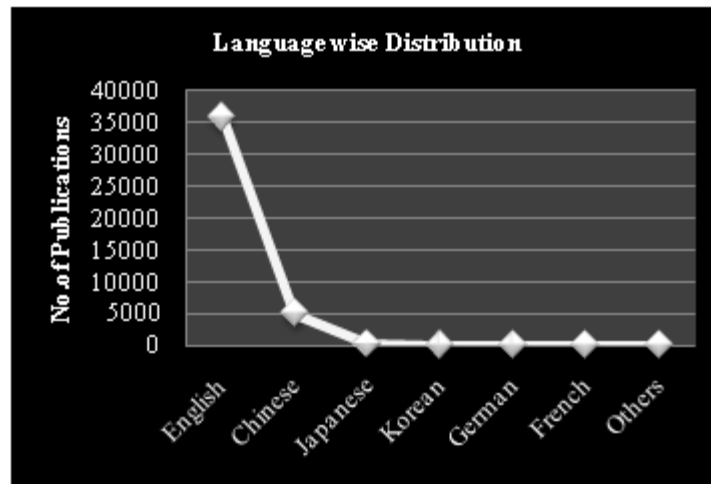


Figure 4: Language Wise Distribution

The majority of documents (86.55 %) published in English Language (Figure 4) which is followed by Chinese (5161 papers), Japanese (295 papers) and Korean (44 papers).

Source Title Wise Distributions

Table 5 indicates that the top 25 journals are used for publishing the research papers.

Table 5: Source Title Wise Distributions

S. No	Source Title	No. of Publications	%
1	Proceedings of the ASME Turbo Expo	1231	2.95
2	Journal of Aircraft	651	1.56
3	AIAA Journal	563	1.35
4	Applied Mechanics And Materials	525	1.26
5	Collection of Technical Papers AIAA ASME ASCE AHS ASC Structures Structural Dynamics and Materials Conference	507	1.22
6	Hangkong Dongli Xuebao Journal of Aerospace Power	483	1.16
7	27th Congress of the International Council of the Aeronautical Sciences 2010 ICAS 2010	475	1.98
8	Collection of Technical Papers AIAA Applied Aerodynamics Conference	404	0.97
9	Hangkong Xuebao Acta Aeronautica Et Astronautica Sinica	394	0.95
10	Advanced Materials Research	390	0.94
11	28th Congress of the International Council of the Aeronautical Sciences 2012 ICAS 2012	378	0.91
12	Proceedings of SPIE the International Society for Optical Engineering	348	0.84

Table 5: Contd.,			
13	Journal of Wind Engineering and Industrial Aerodynamics	343	0.82
14	SAE Technical Papers	342	0.82
15	Journal of Fluid Mechanics	338	0.81
16	Kongqi Donglixue Xuebao Acta Aerodynamica Sinica	325	0.78
17	ICAS Secretariat 26th Congress of International Council of the Aeronautical Sciences 2008 ICAS 2008	316	0.76
18	ICAS Secretariat 25th Congress of the International Council of the Aeronautical Sciences 2006	289	0.69
19	ISSCAA2010 3rd International Symposium on Systems and Control in Aeronautics and Astronautics	284	0.68
20	Collection of Technical papers 44th AIAA Aerospace Sciences Meeting	277	0.67
21	Annual Forum Proceedings AHS International	265	0.64
22	Journal of Turbo machinery	249	0.59
23	Tuijin Jishu Journal of Propulsion Technology	245	0.59
24	Aerospace Science and Technology	242	0.58
25	Others	31764	76.3
Total		41628	100.82

Maximum (1231) papers are published in Proceedings of the ASME Turbo Expo (1231) followed by Journal of Aircraft with 651 publications.

Prolific Affiliations

Affiliations wise distribution of research publications in Aerodynamic is shown in Table 6.

Table 6: Affiliations Wise Distributions

S. No	Affiliation	No. of Publications	%
1	Beihang University	1228	2.95
2	Northwestern Polytechnical University	1218	2.93
3	Nanjing University of Aeronautics and Astronautics	798	1.92
4	Harbin Institute of Technology	723	1.74
5	Deutsches Zentrum fur Luft- Und Raumfahrt	714	1.72
6	NASA Langley Research Center	668	1.60
7	Wright-Patterson AFB	515	1.24
8	Tongji University	458	1.10
9	Japan Aerospace Exploration Agency	417	1.00
10	China Aerodynamics Research and Development Center	405	0.97
11	NASA Ames Research Center	383	0.92
12	Delft University of Technology	383	0.92
13	National University of Defense Technology	377	0.91
14	Tsinghua University	377	0.91
15	Georgia Institute of Technology	351	0.84
16	Boeing Corporation	324	0.78
17	Virginia Polytechnic Institute and State University	323	0.78
18	Xi'an Jiaotong University	313	0.75

Table 6: Contd.,			
19	University Michigan Ann Arbor	312	0.75
20	Politecnico di Milano	284	0.68
107	Indian Institute of Technology, Kanpur	99	0.24
160	Indian Institute of Technology, Madras	69	0.17
21-106 108-159	Others	30889	74.20
Total		41628	100.00

Table 6 shows that Beihang University(1228), Northwestern Polytechnical University(1218), Nanjing University of Aeronautics and Astronautics(798), Harbin Institute of Technology(723) and Deutsches Zentrum für Luft- Und Raumfahrt (714) are the top five Prolific Affiliations in present study. It also indicates that Indian Institute of Technology, Kanpur (99 papers) has 107th place as well as Indian Institute of Technology, Madras occupied in 160th position with 66 papers.

Source Wise Distributions

Research publications in Aerodynamic were contributed from five different source type and the same presented in Table 7.

Table 7: Source Type Wise Distributions

S. No	Source Type	No. of Publications	%
1	Journals	21840	52.48
2	Conference Proceedings	18239	43.82
3	Book Series	1308	3.14
4	Trade Publications	213	0.51
5	Books	28	0.07
Total		41628	100.00

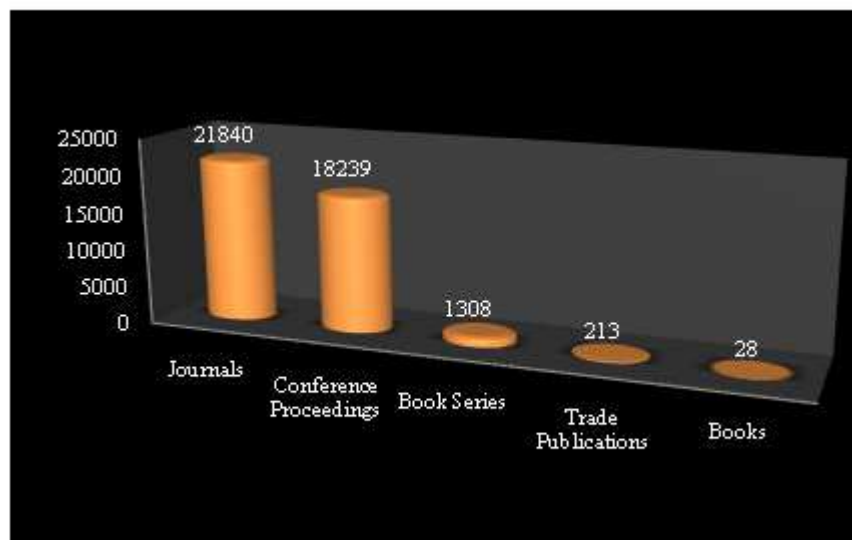


Figure 5: Source Type

Figure 5 explains that Journals got the first rank with 21840 publications followed by Conference Proceedings (18239) and Book Series with 1308 papers.

Keyword Distributions

Table 8 indicates that the most prolific keywords are used in Aerodynamic research publications.

Table 8: Most Preferred Keywords

S. No	Keyword	No. of Publication	% of 41628
1	Aerodynamics	32253	77.48
2	Computational Fluid Dynamics	6144	14.76
3	Wind Tunnels	4530	10.88
4	Computer Simulation	4476	10.75
5	Reynolds Number	3496	8.39
6	Mach Number	3434	8.25
7	Supersonic Aerodynamics	2890	6.94
8	Optimization	2725	6.55
9	Airfoils	2632	6.32
10	Navier Stokes Equations	2588	6.21
11	Design	2574	6.18
12	Flutter (aerodynamics)	2568	6.17
13	Vortex Flow	2438	5.86
14	Hypersonic Aerodynamics	2381	5.72
15	Aircraft	2308	5.54
16	Fluid Dynamics	2101	5.05
17	Boundary Layers	2062	4.95
18	Turbomachine Blades	2039	4.89
19	Aeroelasticity	1980	4.76
20	Mathematical Models	1975	4.74
21	Wind Turbines	1912	4.59
22	Drag	1813	4.36
23	Gas Dynamics	1795	4.31
24	Numerical Simulation	1717	4.12
25	Aerospace Engineering	1688	4.05

Maximum (77.48 %) number of research papers are used the keywords as Aerodynamic followed by Computational Fluid Dynamics (14.76%) rest of them listed in Table 8.

CONCLUSIONS

The present study is to highlight the status and development of research trends in Aerodynamics. They are,

- Maximum (5099) research publication published in 2010 and Minimum (2908) research publications are reported in 2007.
- United States published Maximum with 11551 publications followed by China (11129) publications.
- Maximum number of papers presented in Conference (49.8%) followed by Articles (48.84%).
- Maximum (1231) papers are published in Proceedings of the ASME Turbo Expo (1231) followed by Journal of Aircraft with 651 publications as in source title in Aerodynamic research.

- Regarding Affiliations, Beihang University (1228) is the top Prolific Affiliations in this study. In India, Indian Institute of Technology, Kanpur (99 papers) has 107th place as well as Indian Institute of Technology, Madras occupies in 160th position with 66 papers.

This quantitative analysis are helping tool to analysis and strengthen the research areas in Aerodynamic field.

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